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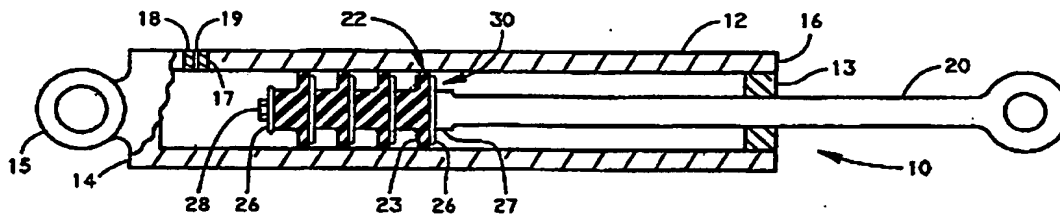
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Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: DUAL-RATE LINEAR DAMPER



(57) Abstract

A plurality of embodiments of dual-rate linear dampers which can be utilized as hold open rods. These dampers provide significantly greater resistance to movement in one direction than in the other and, in one embodiment, effectively lock in the hold open position unless and until the design breakover force is incurred. The comparative resistance to movement in the two linear directions can be altered within the range of between five and ten times the force in the resistive embodiment by varying a number of parameters including, but not limited to, the number of disks in the string, the thickness of the disk flange, the number and depth of grooves in one or both surfaces of the flange, the tapering of the flange, and the properties of the elastomer.

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DUAL-RATE LINEAR DAMPER

Background and Summary of the Invention

5 The present invention is directed to a dual-rate linear damper which provides greater damping in a second direction than in a first direction. One embodiment provides a significant increase in damping to effectively lock the position of the piston rod in position relative to the housing until a particular breakover force is incurred.

10 This aspect of the invention is related to the adjustable, lockable devices described and claimed in commonly assigned U.S. patent application ser. no. 08/ 424,925 filed April 19, 1995, which application is hereby incorporated by reference.

15 As noted in the earlier application, a number of applications require a suitable alternative to gas springs which can provide a first damping force in a first linear direction and a significantly greater resistance to movement in the other linear direction. Certain of these applications require the capability to effectively lock the piston relative to the housing until a particular predetermined breakover force is incurred.

20 Some of these applications include a hold-open rod for clam-shell halves of an engine cowl; the retainer for the door on the overhead luggage compartment in an aircraft cabin; the door covering an aircraft fueling port. While either the resisting or locking embodiments could be used on any of these or other applications, only the fuel door application actually requires the features of the lockable embodiment.

25 The dual-rate linear damper of the present invention employs a plurality of elastomeric disks mounted on a piston rod, each disk having a backing plate in the form of a metal washer. Preferably, each elastomeric disk has a plurality of relief grooves cut in at least one of its faces to facilitate collapse. In a first, typically expanding direction, the elastomeric disks will
30 fold away from the backing disks and provide only minimal resistance to movement while in the second, typically collapsing direction, the backing

plate will reinforce the elastomer and effectively result in bulging of the elastomer into the internal surface of the piston housing. This produces a force resisting movement which is between about five and ten times the resistance to movement in the first direction.

5 The second embodiment provides a locking mechanism for holding the respective door in the open position unless and until a particular breakover force is incurred to prevent damage to the door. That mechanism includes a first elastomeric spring which bulges laterally outwardly under the influence of a second spring. This embodiment utilizes an actuator mechanism which
10 includes a first actuator rod which extends through the first and second springs; a second short rod portion that is biased by a third spring in a direction away from the first actuator rod; and a manually-operable, a laterally extending lever which enables said biasing of said third spring to be overcome, said second rod portion to be brought into engagement with an end
15 of said rod and said rod to be displaced against the biasing force of said second spring to unload said first spring resulting in said resistance force being significantly reduced, whereby said inner cylindrical member can be moved relative to said outer cylindrical member.

20 Various features, advantages and characteristics of the present invention will become apparent after a reading of the following detailed description of the preferred embodiments.

Brief Description of the Drawings

25 The following drawings taken in conjunction with the detailed description, describe several preferred embodiments of the present invention. In the drawings, like reference numerals indicate like features and,

FIG. 1 is a side elevation in partial section of a first embodiment of the damper of the present invention;

30 FIG. 2a is a cross-sectional side view of a first embodiment of elastomeric disk useful in the damper of the present invention;

FIG. 2b is an end view of the disk shown in FIG. 2a;

FIG. 2c is a cross-sectional side view of a second embodiment of disk useful in the damper of the present invention;

FIG. 2d is a cross-sectional side view of a third disk embodiment;

FIG. 3 is an end view of an engine with cowling halves which are held open by the damper of the present invention; and

FIG. 4 is a cross-sectional side view of a second embodiment of the present invention which includes a locking feature.

Detailed Description of the Preferred Embodiments

10 A first embodiment of the dual-rate linear damper of the present invention is depicted in Fig. 1 generally at 10. Damper 10 includes housing 12 and piston rod 20. Housing 12 has a first closed end 14 and an open end 16. A washer 13 which is preferably made of Teflon® polymer, or the like, is positioned in the open end and secured by any conventional manner such as staking, adhesive or a cap member (not shown) could be threaded over the end. Closed end 14 has an attachment eyelet 15 formed thereon and an orifice 17 is provided to permit the air to escape from housing 12 as the piston rod 20 moves in the contracting direction. An adjustable valve element 18 can be provided in order to add air damping to the damping level provided by elastomeric disks 22. Valve element 18 may have one or more slots 19 which taper in order vary the air flow rate permitted into and out of the housing 12.

Piston rod 20 has a plurality of elastomeric disks 22 which are attached thereto in a manner to maintain a spaced relationship. The embodiment depicted in Fig. 1 has four disks 22. It will be appreciated that it is within the scope of the invention to have a plurality of two or more, and more preferably, three or more, disks 22. In this embodiment of disk 22, shown in more detail in Figs. 2a and 2b, each disk includes a cylindrical metal sleeve 24 coated on its external surface by an elastomeric layer 25. A first end of sleeve 24 engages a backing plate 26, which takes the form of a metal washer, while the opposite end engages the back side of another washer 26. First washer 26 engages a shoulder 27 on piston rod 20 and the last washer 26 is held in place by bolt 28 which is threaded into the end of piston

rod 20. Hence, there is metal-to-metal contact throughout the length of the piston head 30 and laterally extending flanges 23 of the series of washers will remain in fixed relative position.

It is an important aspect of the present invention that piston head 30 offer significantly greater damping (i.e., develop a larger resisting force to movement) in one direction than in the other, namely, for the applications envisioned, that the resistance to contracting or collapsing be between five and ten times the resistance to expanding. More particularly, the damping force is preferably about seven times greater in one direction than the other. Some applications which can be envisioned (i.e., some gas spring replacement uses), will require that the disks 22 and backing washer 26 be reversed to implement a greater expanding force than contracting force.

The use of backing washers 26 will necessarily stiffen the elastomer of flange 23 when moving in a direction away from the backing plate. Other steps may be taken to weaken the resistance to movement in the opposing direction. In the first disk embodiment of Figs. 2a and 2b, the under surface of the flange 23 has elastomer removed as indicated by notches 34. This facilitates the flexing of flanges 23 away from backing plates 26 significantly reducing the force exerted against the inner surface of cylinder 12. While these notches are shown extending only partially through the flange 23, for greater flexibility (and ease of manufacture) notches 34 may extend completely through the flange, at some cost to the integrity of the part. The desired flexibility can be varied by varying the thickness of flange 23, the depth and width of notches 34, and the hardness of the elastomer. The diameter of flange 23 is preferably greater than the inside diameter of housing 12 so as to produce between ten and twenty percent precompression of the elastomer when inserted in the housing and, more preferably, about fifteen percent precompression.

Fig. 2c shows a second embodiment of elastomeric disk 22'. In this and in the Fig. 2d embodiment, the spacer function is provided by a separate sleeve element. The integral sleeve configuration is preferred and it will be appreciated the features of these latter two embodiments can be implemented with an integral sleeve as well. In the Fig. 2c embodiment, the flexibility is provided by an annular ring 36' on either or both faces of disk

flange 23'. By varying the number, diameter and surface of the annular ring(s) 36', the flexibility of the disk 22' can be controlled to provide the desired difference in force generated in the two opposing directions.

5 In the Fig. 2d embodiment, flexibility of disk 22" is provided by tapering flange 23". While the tapering surface could conceivably be positioned to face in either direction, it is preferred that the taper face in the direction of the contracting movement (toward the sleeve). Positioning the taper to face in the opposite direction will introduce an amount of lost motion in which flange 23" will be permitted to flex during relative motion between
10 housing 12 and piston rod 20 without any movement between the outer edge of disk 22" and the inner surface of the housing. In some applications, such a lost motion could be desirable, in which case the reversal of disk 22" could be utilized.

Fig. 3 depicts an exemplary application of the damper 10 of the
15 present invention. An aircraft engine cowling is shown with upper half 33 and lower half 35 depicted in their deployed positions permitting servicing of the engine. Normally, two dampers 10 (one shown) will be employed on each cowling half adjacent each end and each will react between its respective cowling half and support 37. Larger cowlings could employ a larger number of dampers 10 or they could simply be made larger to handle the extra weight.
20 Dampers 10 are shown, generally, in their closed positions by dotted lines. When cowling halves 33 and 35 are closed, they will be held in place by fastening their contacting edges together by screws, or the like (not shown). Dampers 10 will open easily because of the low damping force created in the
25 extending direction, and then the larger resistance to contracting force will hold the cowling open until the mechanic desires to shut them. Other applications such as the overhead compartment hold open rods in aircraft cabins would function similarly.

For certain applications, it is desired to effectively lock the element in
30 place, such as, for example, in the case of a hold open rod for a aircraft door on a fuel port. The embodiment depicted in Fig. 4 has such a capability. As described in copending U.S. application serial no. 08/424,925, hold open rod 10' has a piston rod 20' with a piston head 30' which includes an elastomeric spring or sleeve 40'. By axially collapsing sleeve 40' under influence of second

spring 42', sleeve 40' bulges radially and effectively locks piston rod 20' in position relative to housing 12'. Sleeve 40' can be designed to retain this relative position until a predetermined breakover force causes motion. The designing in such a breakover force prevents damage to the retained member
5 when it incurs a force greater than the breakover force.

Actuator mechanism 44' includes a first actuator rod 46' extending through first and second springs 40' and 42'. A second short actuator rod segment 48' is biased away from said first rod 46' by a third spring 50', depicted here as (and preferably being) an elastomeric spring. Second spring
10 42' causes element 52' to axially compress sleeve 40' against flange 54' (through intermediate metallic sleeve 56' and washer 58', respectively) causing the radial bulging which effectively locks piston 20' in place. Once refueling is complete, a manually operative lever 60' which extends transverse to rod segment 48', can be engaged, and while translating in slot 62', made to
15 overcome the bias of third spring 50' such that rod segment 48' engages rod 46', and further translation causes rod 46' to overcome the biasing force of second spring 42' and unloads first spring 40' such that the bulging of the locking device is abated and piston 20' can move within housing 12'. Orifice 17' is provided in the lower portion of housing 12' to permit the escape of
20 entrapped air. As with the previous embodiment, an adjustable valve may be provided if desired to provide a desired level of air damping as a supplement to that of sleeve 40'. Slide bearing 13' for piston rod 20' is held in position by circlip 27'. The ends of housing 12' are closed by end caps received in complementary shaped openings and a similar end cap could replace bearing
25 13' and circlip 27'.

Disclosed herein are a plurality of embodiments of dual-rate linear dampers which can be utilized as hold open rods. These dampers provide significantly greater resistance to movement in one direction than in the other and, in one embodiment, effectively lock in the hold open position unless and
30 until the design breakover force is incurred. The comparative resistance to movement in the two linear directions can be altered within the range of between five and ten times the force in the resistive embodiment by varying a number of parameters including, but not limited to, the number of disks in the string, the thickness of the disk flange, the number and depth of grooves in

one or both surfaces of the flange, the tapering of the flange, and the properties of the elastomer.

5 Various changes, alternatives and modifications will become apparent to one of ordinary skill in the art following a reading of the foregoing specification. For example, load spring 42' could obviously be positioned on the other end of first rod 46' without affecting the operation of the device. It is intended that all such changes, alternatives and modifications as come within the scope of the appended claims be considered part of the present invention.

Claims

What is claimed is:

1. A dual-rate linear damper having a first damping rate in a first direction and a second greater rate of damping in a second opposite direction,
5 said dual-rate, linear damper comprising

a) a cylindrical housing having an inner peripheral wall with a first internal dimension and a longitudinal center line;

b) a piston rod having a second outer external dimension less than said first internal dimension;

10 c) a series of elastomeric disk elements mounted upon and spaced along said piston rod, each elastomeric disk element having a third radial dimension which slightly exceeds said first internal dimension and is substantially greater than said disk element's axial dimension, said disk element also having
15 a lateral surface portion which engages said inner peripheral wall of said cylindrical housing;

d) a backing plate for each disk element, said backing plate being positioned on the trailing side of said disk element when said piston rod is moving in said second direction and having a
20 fourth radial dimension which exceeds said second outer external dimension but is less than said first internal dimension;

e) each elastomeric disk element including relief means to permit increased flexibility when said piston rod is moving in said first direction, said relief means enabling said lateral
25 surface portion of said disk element to flex inwardly toward said center line while said rod is moving in said first direction;

whereby said backing plate effectively stiffens said disk element when said piston rod is moving in said second direction giving a

greater area of contact between said lateral surface portion and said inner peripheral wall and hence, a higher level of damping.

2. The dual-rate linear damper of Claim 1 further comprising means to maintain a fixed spacing between said plurality of disk elements.

5 3. The dual-rate linear damper of Claim 2 wherein said means to maintain a fixed spacing comprises a metallic sleeve formed integrally with each disk element, said sleeve encircling said piston rod.

10 4. The dual-rate linear damper of Claim 3 wherein each said backing plate comprises a metallic washer stacked in series between a pair of elastomeric disk elements.

5. The dual-rate linear damper of Claim 1 wherein said relief means comprises one or more grooves formed in a first surface of each said disk without extending through a second opposite surface.

15 6. The dual-rate linear damper of Claim 1 wherein said relief means comprises a tapered flange formed upon said elastomeric disk, said tapered flange enabling said lateral surface portion of said disk element to flex inwardly toward said center line when said piston rod is moving in said first direction.

20 7. The dual-rate linear damper of Claim 1 further comprising an orifice formed in said housing adjacent a distal end thereof.

8. The dual-rate linear damper of Claim 7 further comprising adjustable valve means to vary an auxiliary level of air damping.

25 9. The dual-rate linear damper of Claim 1 wherein said series of elastomeric disks includes at least three elastomeric disks held in spaced relationship with respect to each other.

10. The dual-rate linear damper of Claim 1 wherein each elastomeric disk in said series is precompressed when inserted within said cylindrical housing by an amount in the range of between 10% and 20%.

11. The dual-rate linear damper of Claim 10 wherein each elastomeric disk is more preferably precompressed by an amount of about 15%.

5 12. The dual-rate linear damper of Claim 1 wherein said second damping rate provides a second force resisting motion in said second direction which is between five and ten times a first corresponding force produced by said first damping rate resisting motion in said first direction.

10 13. The dual-rate linear damper of Claim 12 wherein said damper most preferably provides a second force which is about seven times said first force.

14. The dual-rate linear damper of Claim 1 wherein said first direction is an extending direction for said piston rod relative to said housing and said second direction is a contracting direction.

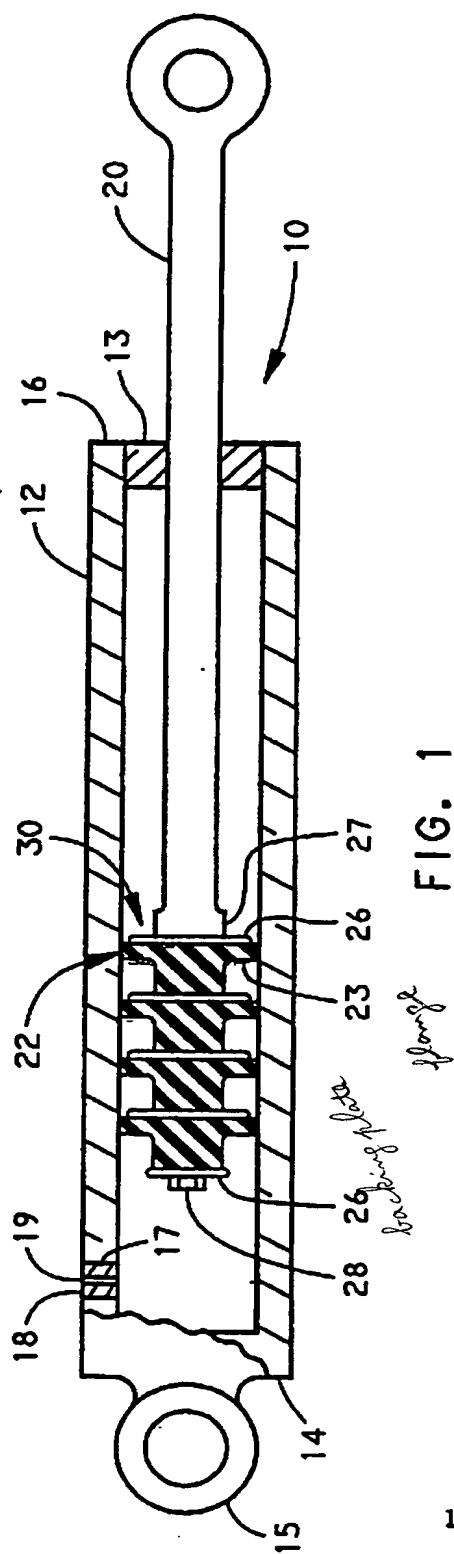
15 15. An adjustable, lockable strut including an outer cylindrical member having an inner periphery, an inner cylindrical member having an outer periphery, locking means including a first spring member surrounding at least a portion of said outer periphery of said inner cylindrical member and engaging at least a portion of said inner periphery of said outer cylindrical member, a second spring member loading said first spring member and
20 causing it to undergo radial bulging thereby increasing a resistance force exerted by said first spring member to movement between said inner and outer cylindrical members, an actuator moving said second spring member from a first bulge-producing position to a second inoperative position where said resistance force is significantly reduced, the improvement comprising

25 said actuator including

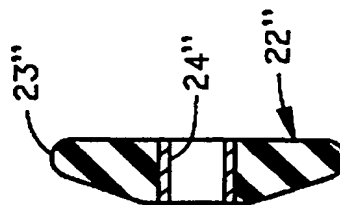
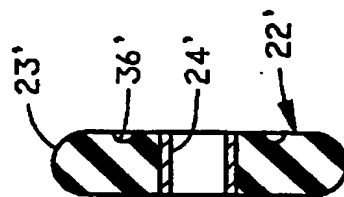
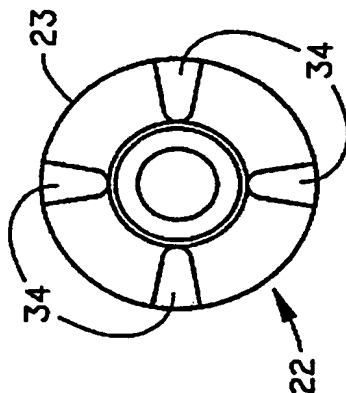
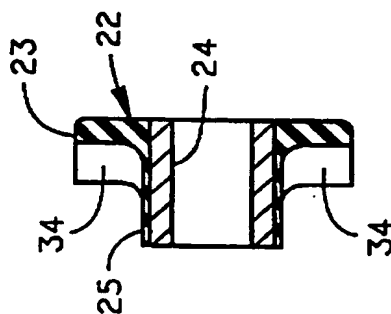
- a) a first rod extending through said first and second springs;
- b) a shorter second rod portion coaxial with said first rod;
- c) a third spring biasing said second rod portion into a first non-engaging position with respect to said first rod;

5 d) a manually-operable, laterally extending lever which enables said biasing of said third spring to be overcome, said second rod portion to be brought into engagement with an end of said rod and said rod to be displaced against the biasing force of said second spring to unload said first spring resulting in said resistance force being significantly reduced whereby said inner cylindrical member can be moved relative to said outer cylindrical member.

16. The adjustable, lockable strut of Claim 15 wherein said third spring comprises an elastomeric spring.



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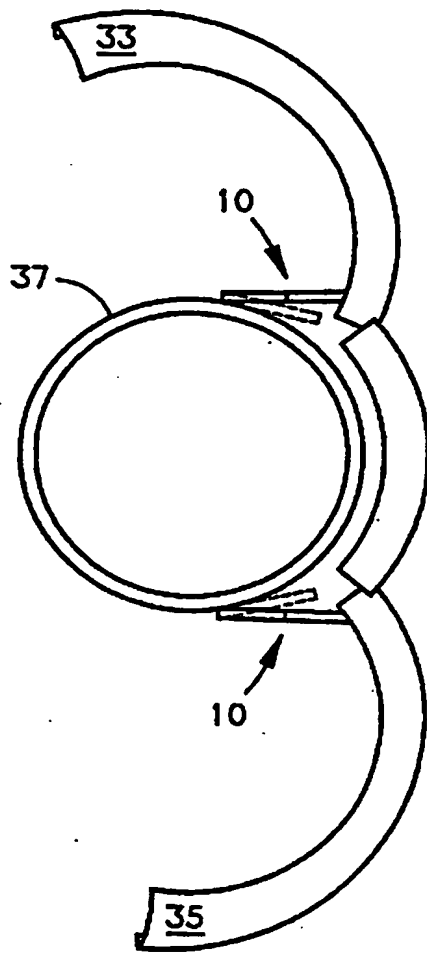


FIG. 3

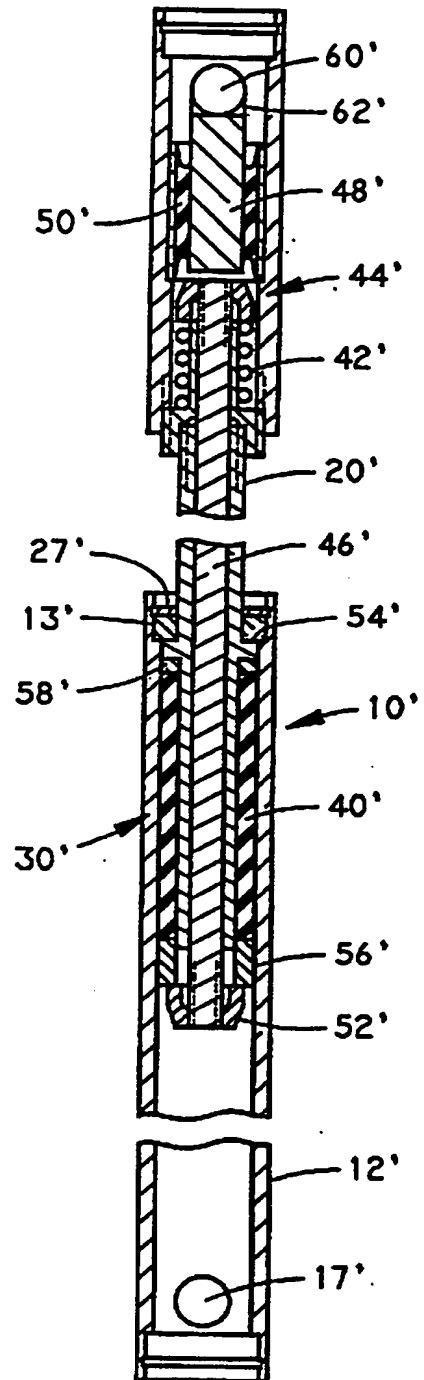


FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/04129

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 F16F7/09 F16F9/56 F16B7/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 F16F F16B A47C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	BE,A,548 536 (G. VAN IEPEREN) 20 November 1959 see the whole document	1,2,9-13
Y	---	3,4,7,8
A	---	5
Y	FR,E,70 249 (G.-A. OLIVIER) 25 March 1959 see page E	7,8
Y	---	---
Y	US,A,3 831 920 (MELDRUM C ET AL) 27 August 1974 see column 3, line 3 - line 10; figures	3,4
A	---	---
A	GB,A,824 407 (P. ALBERT) 25 November 1959 see the whole document	1
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

20 November 1996

Date of mailing of the international search report

27. 11. 96

Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/04129

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR,A,1 405 156 (F. WAGNER ET AL.) 2 July 1965 see the whole document ---	1
A	US,A,2 752 149 (R. FORCELLINI) 26 June 1956 see column 3, line 52 - line 74 ---	7,8
A	DE,C,876 164 (M. SÖRENSEN) 13 June 1953 see the whole document ---	15
A	GB,A,2 241 995 (HARWOOD COLIN JOSEPH) 18 September 1991 see the whole document ---	15
A	DE,U,19 55 308 (FRANZ KIEL GMBH) 9 February 1967 see claim 2; figure 2 ---	15
A	US,A,3 790 119 (BAUER F) 5 February 1974 see figure 2 ---	15
A	FR,A,1 174 675 (M.-R. PLOQUIN) 13 March 1959 see the whole document ---	15
A	FR,A,1 111 735 (R. DEPOIT) 5 March 1956 see the whole document ---	15
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INTERNATIONAL SEARCH REPORT

national application No.

PCT/US 96/04129

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

CLAIMS 1-14 : A DUAL-RATE LINEAR DAMPER
CLAIMS 15,16 : AN ADJUSTABLE LOCKABLE STRUT

1. ☒ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 96/04129

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INTERNATIONAL SEARCH REPORT

information on patent family members

Inter. Appl. No.
PCT/US 96/04129

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